

# ROI in UX Design: Preliminary Evidence from Interviews with Industry Professionals

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**Abstract.** *Measuring business outcomes in UX Design is essential for establishing design as a strategic practice within organizations. However, despite growing interest in demonstrating UX value, this measurement remains poorly structured in professional practice. This paper investigates the characteristics of business outcome measurement in UX Design, focusing on the metrics adopted, the perceived relevance of this practice, and the main challenges involved. We conducted semi-structured interviews with ten UX professionals from different organizations and analyzed the data through open coding and thematic analysis. The findings show that professionals perceive measurement not only as a way to assess financial return, but also as a strategic mechanism for legitimizing UX, supporting prioritization, and communicating value to stakeholders. Participants reported combining financial and behavioral metrics, while relying mainly on operational tools rather than formal ROI frameworks. The main barriers identified were organizational and cultural, including lack of structure, limited recognition of UX, and difficulties in isolating the impact of design on business outcomes. As a practical contribution, we summarize four action-oriented recommendations to support more mature and data-driven UX measurement practices.*

**Keywords:** User eXperience (UX), Return on Investment (ROI), UX Measurement, Business Impact.

## 1. Introduction

Studies show that User eXperience (UX) Design contributes to better financial results, customer loyalty, and reduced customer service costs [Trendowicz et al. 2023][Adebesin and Chawana 2021][Aleryani 2020]. In this context, UX Design is a process that focuses on developing user-centered digital solutions that meet their needs and expectations [Borriraklert and Kiattisin 2021]. Beyond usability, it seeks to improve the overall journey through more efficient and satisfying experiences [Horvath 2020].

Measuring the Return on Investment (ROI) in UX Design has become essential to justify efforts and align them with strategic objectives [Adebesin and Chawana 2021]. Although some frameworks have been built, empirical evidence on how UX professionals measure ROI in practice is still limited [Stige et al. 2023]. This limitation persists because measuring ROI in UX Design is not only a conceptual challenge but also an operational one [Trendowicz et al. 2023]. While the relevance of UX metrics is widely

recognized, professionals still face difficulties in defining, justifying, and systematically applying them in real-world projects [Chow and Croxton 2014].

In many cases, UX outcomes are not translated into actionable measurement artifacts, such as explicit indicators, formulas, data sources, and structured evaluation plans, which weakens their practical use in organizational decision-making [Adebesin and Chawana 2021]. Furthermore, existing approaches often remain at a high level of abstraction or focus on post-hoc monitoring, offering limited support for continuous measurement at the functionality level throughout the development cycle [Aleryani 2020]. As a result, ROI measurement in UX is often conducted in an ad hoc and inconsistent manner, contributing to a lack of empirical evidence on how professionals operationalize it in practice [Horvath 2020].

To explore these limitations, this article addresses the following Research Question (RQ): *What are the characteristics of ROI measurement in UX Design?* Specifically, it investigates the metrics adopted, the objectives pursued, and the challenges associated with this process in the context of digital products. To this end, semi-structured interviews were conducted with ten UX professionals from different organizations. The qualitative data were analyzed using open coding followed by thematic analysis [Saldaña 2016]. The findings reveal that professionals mainly measure ROI in UX Design to communicate the strategic value of UX to stakeholders, demonstrate the relevance of their work, and strengthen professional recognition within organizations.

The results also show that ROI measurement is typically based on a combination of financial indicators and UX-related metrics, such as user satisfaction, product usage, and engagement, although these combinations are rarely guided by explicit or standardized criteria. In addition, the study highlights significant barriers to ROI measurement, particularly the lack of a structured measurement process, often requiring dependence on other teams to track relevant metrics, as well as the difficulty of isolating variables to determine whether observed business outcomes can in fact be attributed to UX improvements.

As a contribution, we propose four practical actions based on the takeaways to support the development of more mature and data-driven measurement practices in UX Design. The structure of the article includes: Related Work (Section 2), Research Design (Section 3), Results (Section 4), Discussion and Practical Actions (Section 5), and Final Considerations (Section 6).

## **2. Related Work**

The relationship between UX Design and business performance has gained increasing attention in the literature, particularly as organizations seek to justify design investments and align UX activities with strategic objectives [Stige et al. 2023, Horvath 2020]. In this context, prior studies suggest that UX can generate both user-centered and organizational benefits, including improved usability, customer satisfaction, reduced support costs, and stronger business outcomes [Aleryani 2020, Berni et al. 2023]. However, despite this growing recognition, the measurement of ROI in UX Design remains fragmented and methodologically challenging.

One recurring discussion in the literature concerns the use of metrics to demonstrate the value of UX. Researchers have highlighted the relevance of combining tradi-

tional UX and usability measures, such as task completion rate, time on task, and user satisfaction, with broader business indicators, including customer loyalty, retention, and financial performance [Albert and Tullis 2013, Adebessin and Chawana 2021]. This perspective reinforces the idea that UX evaluation should not be restricted to interaction quality alone but should also consider how design decisions affect organizational outcomes [Berni et al. 2023, Trendowicz et al. 2023]. At the same time, the literature indicates that selecting and operationalizing such metrics is not straightforward, especially when UX outcomes are indirect, long-term, or influenced by multiple variables [Sauro 2016].

Another important stream of research focuses on methods and models for justifying UX investments. Existing studies have proposed decision-support approaches to estimate or prioritize the value of usability and UX interventions. For instance, Aydin and Beruvides [Aydin and Beruvides 2014] developed a decision tool based on regression analysis and Pareto analysis to support usability cost justification, while Adebessin and Chawana [Adebessin and Chawana 2021] discuss the use of conjoint analysis as a way to estimate expected UX return before implementation. Similarly, Horvath [Horvath 2020] argues that UX value should be approached at an institutional level, embedded in broader organizational structures and decision-making processes. Together, these contributions demonstrate that ROI in UX has been approached not only as an evaluative concern, but also as a managerial and strategic problem.

The literature also includes empirical evidence suggesting that UX improvements can lead to substantial business gains. Case-based and multivocal studies report that design interventions may contribute to increased sales, improved conversion, greater efficiency, and stronger user adoption [Trendowicz et al. 2023, Chow and Croxton 2014]. These findings reinforce the argument that UX can produce measurable value when linked to concrete business outcomes. However, most prior work has emphasized either frameworks, methods, or isolated success cases, often focusing on *how* ROI could be measured rather than on *how practitioners actually perceive, interpret, and operationalize this measurement in real organizational contexts*.

Therefore, although prior studies provide important contributions regarding UX metrics, investment justification, and business value, there is still limited empirical understanding of how industry professionals make sense of ROI measurement in UX Design in practice. In particular, the literature remains underexplored regarding: (i) which metrics professionals actually associate with UX ROI, (ii) why they consider business outcome measurement important in their work, and (iii) what challenges they face when attempting to connect UX activities to measurable business results.

### **3. Research Design**

The qualitative study aimed to explore characteristics (i.e., metrics, objectives, and challenges) involved in measuring ROI in UX Design. To carry out the study, semi-structured interviews were conducted with ten UX professionals from different Brazilian organizations. The open coding technique was applied to analyze the qualitative data gathered followed by a thematic analysis [Saldaña 2016]. The study adopted the protocol that includes the steps: **(1)** Definition of Research Questions, splitting the main RQ and Data Collection; and **(2)** Data Extraction and Analysis.

The study was conducted by the first author/researcher (R1), with the collabora-

tion of the second author (R2). R1 is a researcher with eight years of experience in product research, while R2 is a senior researcher with more than fifteen years of experience in UX Design research in the industry.

### 3.1. Research Questions and Data Collection

From the main RQ: *What are the characteristics of ROI measurement in UX Design?*, three questions were elaborated to allow for a more specific exploration of the results:

- **RQ1)** What is the relevance of measuring business outcomes in UX Design?
- **RQ2)** What metrics and tools are used?
- **RQ3)** What are the main challenges?

The interview questions were composed of profile questions plus questions elaborated based on the research questions. Table 1 presents the questions and the justification for each question in the interview. Questions Q1 to Q3 are specifically related to the participants' profiles.

**Table 1. Semi-structured interview questions.**

ID	Question	Justification
Q1	What is your city/state of residence?	Identify the participant's region
Q2	What is your current job title?	Validate if the person belongs to the target sample
Q3	What level of seniority do you identify with?	Understand experience in the field
Q4	Tell us about your daily UX Design routine.	Confirm active work with UX Design
Q5	What do you understand by ROI?	Validate participant's understanding
Q6	Is it important to measure ROI? Why?	Understand perceived relevance of measuring ROI
Q7	Have you measured ROI in UX? How?	Understand measurement experience
Q8	Does your company measure UX impact? How?	Measurement is a culture of the company
Q9	What metrics have you used?	Map metrics used
Q10	Are current metrics effective? Improvements?	Identify gaps and opportunities
Q11	Do you use any ROI tools?	Identify tools used
Q12	What are the main challenges?	Understand barriers in measurement
Q13	Who cares most about UX metrics/ROI?	Identify key stakeholders
Q14	Have you justified UX impact internally?	Understand communication challenges

Before conducting the official interviews, a pilot test was conducted with two UX Design professionals to ensure the interviews were not too long and that the research objective was achieved. The pilot indicated that no adjustments were needed. The interviews conducted as a pilot test were not included in the data extraction and analysis.

Participants were recruited through the research group's social media channels (i.e., LinkedIn) by inviting professionals who are part of the research group's network. Since there were already established contacts within the UX field, it was possible to identify potential interviewees. The invitation included a brief description of the research purpose. In total, ten participants were interviewed between March and April 2025 (see Table 2 for details on City/State, Position, and Seniority).

All interviews were conducted online via Google Meet<sup>1</sup>, and none of them exceeded one hour in duration. R1 conducted the interviews, following a five-step script

<sup>1</sup>Google Meet is a videoconferencing platform developed by Google.

**Table 2. Profile of the participants (all Brazilians).**

Participant	City/State	Job Position	Job Level
P1	São Carlos/São Paulo	Product Designer	Senior
P2	Ribeirão Preto/São Paulo	Product Designer	Mid-level
P3	Campinas/São Paulo	Product Manager	Senior
P4	São Paulo/São Paulo	UX Designer Conversational	Entry-level
P5	São Paulo/São Paulo	Product Manager	Senior
P6	Belo Horizonte/Minas Gerais	Product Designer	Senior
P7	Feira de Santana/Bahia	Product Manager	Senior
P8	São Paulo/São Paulo	Product Designer	Entry-level
P9	Ribeirão Preto/São Paulo	Product Manager	Mid-level
P10	Sorocaba/São Paulo	Product Manager	Senior

to ensure consistency across all sessions: (i) the purpose of the study and the interview steps were explained to the participants. (ii) participants completed an online consent form before the interviews by accepting to take part of the study; (iii) they responded to profile questions about their experience; (iv) they answered questions Q3 to Q14 (see Table 1); and (v) at the end, participants were invited to share any additional comments regarding their experiences measuring business outcomes in UX Design. The interviews were recorded using Google Meet itself, resulting in a total of 3 hours and 36 minutes of video plus audio recordings.

### 3.2. Data Extraction and Analysis

The audio recordings were transcribed manually to text format by R1. The transcription was first labeled to identify each part of the text with the questions asked. Data analysis followed a qualitative approach, structured in three rounds of open coding [Saldaña 2016]. Open coding is a qualitative analysis technique in which textual data (e.g., interview transcripts, observation notes, or documents) are systematically labeled with codes that represent relevant concepts or categories [Saldaña 2016]. The goal is to organize and structure the data in a way that facilitates pattern identification, comparison, and interpretation. To ensure analytical transparency and rigor, we include an example of the coding process.

#### Example

**Extracted Excerpt:** “Having this perspective is a huge differentiator (business mindset). Very few UX Designers I’ve worked with had this kind of vision. Many focus only on the experience, without deeply understanding the business or how the data connects to outcomes.”

**Code:** Lack of business vision in the UX field.

**Code Description:** Reflects a perceived gap in the UX field, where many professionals prioritize interface design over a deeper understanding of business goals, market context, and the connection between UX decisions and measurable business outcomes.

In the first round, R1 conducted open coding on participants’ responses. In this phase, excerpts were extracted, and codes emerged directly from the analyzed texts. After labeling all responses, R1 revisited the data, interpreting them according to the coding and developing descriptions for each research question. Subsequently, a thematic analysis was applied to group related codes into broader themes that reflect recurring patterns across participants’ responses.

In the second round, R2 reviewed all the assigned codes and respective findings for each question in the thematic analysis. R2 updated the analysis with new insights when

necessary. Finally, during the last round, R1 and R2 conducted a consensus meeting to consolidate the final set of findings. All extractions and grouped codes are presented in the link to review the collected excerpts <sup>2</sup>.

### 3.3. Threats to Validity

Some threats to the validity of this study must be acknowledged. First, the open participant selection may have introduced variability in experience levels and perspectives. To mitigate this, participants' backgrounds were cross-validated based on their seniority, roles, and involvement in UX initiatives, ensuring relevant practical expertise. Second, the inherent subjectivity of qualitative analysis poses a risk of researcher bias during open coding. To reduce this threat, the analysis involved multiple iterative coding rounds and review by a second researcher, with discrepancies resolved collaboratively. Thematic analysis also supported the identification of recurring patterns across participants, strengthening analytical consistency and credibility of the findings.

## 4. Results

The results are presented by answering the RQ (RQ1-RQ3) in the next sections. We include selected interview excerpts as examples of the data supporting the findings. Since all interviews were conducted in the participants' native language (Brazilian Portuguese), the excerpts presented here have been freely translated from the original statements. Percentages represent the proportion of coded thematic occurrences across categories, considering that some extracts were associated with more than one thematic category.

### 4.1. RQ1: What is the relevance of measuring business outcomes in UX Design?

A total of 38 excerpts related to the relevance of measuring business outcomes in UX Design were identified. Thematic analysis grouped these excerpts into six themes, as shown in Table 3.

The findings indicate that measuring business outcomes in UX Design is primarily perceived as a way to strengthen the connection between design and business strategy. Participants frequently emphasized that measurement helps demonstrate whether UX initiatives are truly contributing to organizational goals, supporting decision-making, and translating design value into terms that leadership can understand. This is illustrated in statements such as *"Measuring ROI correctly allows us to know whether a product should continue or be discontinued"* (P5) and *"The business wants to know how we'll impact their metrics."* (P1). These findings reinforce the prominence of the categories **Strategic Business Vision** and **Product Impact and Financial Results**, which were the most recurrent in the analyses.

In addition, participants associated measurement with the ability to validate initiatives, prioritize efforts, and justify the relevance of UX work within organizations. Some extracts showed that measurement supports decisions about where to invest resources and how to avoid waste, as reflected in statements such as *"Without measurement, we'd just be delivering out of vanity"* (P3) and *"It's hard to prioritize what we can't measure."* (P1). At the same time, participants also linked outcome measurement to professional recognition and stakeholder communication, arguing that demonstrating financial or operational

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<sup>2</sup><https://bit.ly/extractions-code-interview>

**Table 3. Thematic categories on business outcome measurement in UX Design based on interview data.**

Thematic Category	Percentage	Meaning
Strategic Business Vision	26.32%	Measurement is viewed as an essential tool for aligning design with business goals and influencing strategic decisions, as well as communicating UX value to leadership.
Product Impact and Financial Results	26.32%	UX changes lead to financial impact, demonstrable through data—from conversion increases to cost reductions.
Professional Growth and Recognition	18.42%	Measuring outcomes strengthens the professional and team positioning, increasing visibility and market value.
Validation and Prioritization of Initiatives	10.53%	Without measurement, it's impossible to determine whether deliverables create real value. Data supports prioritization of impactful initiatives and avoids resource waste.
Operational Efficiency	10.53%	Measured UX reveals efficiency gains—by optimizing flows, reducing support costs, or streamlining processes.
Facilitating Stakeholder Communication	7.89%	Measurement enables designers to speak the “language of business,” easing proposal acceptance and backing ideas with data.

impact increases the legitimacy of UX work. This is exemplified by extracts such as “*It helps me gain recognition and justify promotions*” (P2) and “*Measuring ROI helps me speak leadership’s language*” (P1). Overall, the results suggest that business outcome measurement in UX is not perceived only as a financial exercise, but as a strategic, communicative, and legitimizing practice.

#### 4.2. RQ2: What metrics and tools are used?

A total of 15 excerpts were identified regarding the metrics and tools used to measure business outcomes in UX Design. Through thematic analysis, the excerpts were consolidated into four overarching themes, as outlined in Table 4.

**Table 4. Thematic categories on types of metrics used in UX Design.**

Thematic Category	Percentage	Category Meaning
Financial Metrics	40.00%	Metrics that indicate financial return, including direct gains (such as revenue and average ticket size) and indirect ones (such as retention, reputation, and cost reduction).
Satisfaction and Usage Metrics	40.00%	Metrics that assess user behavior, task efficiency, engagement, and perceived value in ongoing product use.
Analysis and Measurement Tools	13.33%	Tools used to collect, cross-check, validate, and interpret quantitative and behavioral data about the digital product.
Frameworks and Metric Models	6.67%	Structured use of models and frameworks (such as HEART) that support the definition and application of experience and product success metrics.

The results show that participants reported using different types of metrics to assess business outcomes in UX Design, with a predominance of **Financial Metrics** and

**Satisfaction and Usage Metrics.** Financial metrics were associated with the measurement of direct or indirect returns, such as increased revenue, cost reduction, and retention. This can be observed in extracts such as “*After the first sprint, we could already calculate ROI based on IVR retention versus human support*” (P3) and “*We’re working on reducing Contact Rate (CR), a metric that affects profits*” (P4), which illustrate the concern with linking UX to concrete indicators of organizational performance. In turn, satisfaction and usage metrics were mentioned in situations involving conversion, engagement, user perception, and interaction efficiency, as reflected in statements such as “*We track two things: Business impact (e.g., conversion funnel) and user perception*” (P8) and “*Optimized onboarding [...] Result: increased conversion and completeness rates*” (P10).

Beyond the metrics themselves, participants also referred to the use of analysis and measurement tools and, less frequently, frameworks and structured metric models. These resources appear as support for collecting, cross-referencing, and interpreting data about user behavior and product performance. This is exemplified in extracts such as “*We ran A/B tests using GA and found increased add-on conversion*” (P7) and “*At Witel, I work in CX with the BI team, focusing on data*” (P9), which demonstrate the articulation between UX, analytics, and business intelligence. To a lesser extent, participants also mentioned more structured approaches to guide measurement, suggesting that although still not widespread, frameworks and metric models are beginning to emerge in professional practice.

### 4.3. RQ3: What are the main challenges?

A total of 27 excerpts were identified regarding the challenges faced in measuring business outcomes in UX Design. By applying thematic analysis, the excerpts were classified into the categories detailed in Table 5.

**Table 5. Thematic categories on barriers to measuring business outcomes in UX Design based on interview data.**

Thematic Category	Percentage	Meaning
Organizational Culture and UX Recognition	20.51%	Cultural barriers and difficulties in demonstrating the value of UX to the organization.
Lack of Structure and Measurement Processes	17.95%	Absence of clear processes, tracking systems, and formal analytical structures.
Technical Difficulties and Dependencies	17.95%	Technology limitations, data inconsistencies, and dependency on other teams and systems.
Variable Isolation and Causality	12.82%	Challenges in attributing outcomes to specific UX changes due to external or simultaneous factors.
Inadequate or Poorly Defined Metrics	10.26%	Lack of definition or inappropriate selection of metrics to evaluate UX impact.
Complexity in Communicating Results	10.26%	Difficulty translating UX data into understandable and actionable insights for decision-making.
Resistance from Internal Teams	10.26%	Distrust, underestimation, or resistance to the UX area from other departments (e.g., development, business).

The results indicate that the challenges of measuring business outcomes in UX Design are primarily associated with **Organizational culture and UX recognition**, as

well as with the **Lack of structure and measurement processes**. Participants frequently reported that UX is still undervalued in many organizations and that demonstrating its strategic contribution remains difficult. This can be observed in extracts such as “*Companies can cut half the UX team without ‘breaking’, because no one knew how to sell the area’s strategic relevance*” (P3) and “*Design is often seen as aesthetic. Showing financial or business value proves its true role*” (P6), which illustrate the struggle for legitimacy and recognition of UX work. In parallel, participants also highlighted the absence of formal processes, structured tracking, and routine practices for business outcome measurement, as reflected in statements such as “*In practice, there was no direct measurement of business outcomes in UX*” (P9) and “*There were no structured validation processes*” (P10).

Other recurrent challenges involved **technical difficulties and dependencies**, **variable isolation and causality**, and difficulties in **communicating results**. Participants emphasized that even when there is an intention to measure impact, technical limitations, fragmented data, and dependencies on other teams often hinder the process. This is exemplified in extracts such as “*Revenue isn’t under our control, so decisions depend on other teams*” (P4) and “*Sometimes, our main focus is user experience*” (P7), which suggest that isolating the specific contribution of UX to business outcomes is not always straightforward. In addition, participants reported that communicating results to stakeholders remains a challenge, especially when UX evidence is not easily translated into the “*language of business.*” (P3). Overall, the findings suggest that the barriers to measuring UX business outcomes are not only methodological or technical but also cultural and organizational.

## 5. Discussion and Practical Actions

This study addressed the RQ: *What are the characteristics of ROI measurement in UX Design?* From the perspective of industry professionals, the findings show that business outcome measurement in UX goes beyond financial evaluation and is understood as a strategic practice related to decision-making, legitimacy, and organizational alignment.

First, the results reinforce prior literature that highlights the importance of connecting UX to business performance [Horvath 2020, Berni et al. 2023, Trendowicz et al. 2023]. Participants emphasized measurement as a way to justify UX work and influence strategic decisions, aligning with studies that advocate combining UX and business metrics [Adebesin and Chawana 2021, Albert and Tullis 2013]. However, this study extends existing knowledge by showing that, in practice, measurement is also used to strengthen the perceived legitimacy of UX within organizations, not only to evaluate outcomes.

Second, regarding metrics and tools, the findings confirm that professionals combine financial indicators with behavioral and perceptual metrics [Albert and Tullis 2013, Reichheld 2003, Dixon et al. 2010, Berni et al. 2023], supporting the view that UX value is multidimensional [Sauro 2016]. Nevertheless, the results indicate that formal frameworks and structured ROI models remain underutilized in practice, complementing prior studies that propose decision-support approaches [Aydin and Beruvides 2014, Adebesin and Chawana 2021]. Instead, practitioners rely primarily on operational metrics and existing analytics infrastructures.

Third, the main challenges identified are predominantly organizational rather than purely technical. While the literature points to methodological complexity in measuring UX ROI [Adebessin and Chawana 2021], the findings reveal that cultural barriers, lack of structured processes, and cross-team dependencies play a central role. In addition, the difficulty of isolating the impact of UX on business outcomes reinforces prior discussions on causality limitations [Karat and Karat 2020], suggesting that UX impact is often contributory rather than strictly causal.

Overall, these findings indicate that measuring business outcomes in UX Design should be understood as a socio-technical and organizational practice. This study contributes by providing empirical evidence from industry that bridges the gap between conceptual approaches to UX ROI and its practical application. Beyond these analytical insights, the findings also suggest practical implications for organizations seeking to structure UX measurement practices. Table 6 summarizes four practical actions derived from the interviews.

**Table 6. Practical actions derived from the interview findings.**

Practical Action	Description
1) Choose Strategic Metrics	Combine business (e.g., revenue, conversion, cost) and UX metrics (e.g., engagement, satisfaction) to demonstrate value.
2) Use Standardized Tools	Adopt shared tools (e.g., analytics, dashboards, A/B testing) to improve consistency and evidence quality.
3) Engage Stakeholders	Involve leadership and cross-functional teams to align expectations and support decision-making.
4) Improve Practices Continuously	Treat measurement as iterative by defining KPIs early and refining them over time.

Taken together, these actions reinforce that effective UX measurement depends not only on metrics, but also on organizational alignment and continuous learning.

## 6. Final Considerations

This study investigated the characteristics of business outcome measurement in UX Design from the perspective of industry professionals. The findings show that, although measurement is recognized as strategically relevant, its adoption remains fragmented and influenced by organizational, cultural, and technical barriers. Thus, measuring UX business outcomes should be understood not only as an analytical activity, but also as an organizational practice.

This paper contributes preliminary empirical evidence on how professionals understand and operationalize this measurement in practice, as well as four practical actions to support more mature and data-driven UX measurement practices. As future work, further studies could investigate this topic across different organizational contexts and advance practical frameworks that better connect UX initiatives to business and financial outcomes. Ultimately, strengthening UX measurement depends not only on better metrics, but also on fostering a culture that recognizes design as a strategic source of value.

## Declaration of Generative AI Use

During the preparation of this manuscript, the authors used Claude (Anthropic, version Sonnet 4.5) to assist

with English language correction and academic writing refinement, and for the generation and adjustment of data visualisations presented in the results section. These tools were applied exclusively to improve clarity, linguistic accuracy, and visual presentation of content that was entirely conceived, analysed, and interpreted by the authors. The authors reviewed and verified all AI-assisted output and take full responsibility for the integrity and accuracy of the published work. This work is also part of UFSCar's Cátedra Computação Inteligente Centrada no Humano.

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